Flywheels

Voltage Ride-Through Technology

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Customer Technology Applications Division
Energy Services Division

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Flywheels

An Artistic Definition?

- The defining property of the flywheel is the spinning of a body on an axis. That single property can be as frivolous as the dancing of a child's top or as profound as the very rotation of the earth.
- The flywheel is both ancient and cutting-edge. It enables the steady rhythm of the potter's wheel, inspires the balance and orientation of the gyroscope, and will conserve the momentum of our autos in the future.
- This "magic" harnessing of a natural force ignites the imagination and rivets attention.

Source: Flywheel Publishing Website

Flywheels
A Marketer's Definition?

- A practically lossless system, for converting and storing electricity, as the kinetic energy of a magnetically levitated rotor assembly that spins in a vacuum, and regenerating power as needed. It will enable ultra-reliable, care-free electricity, and non-polluting sustainable on-site alternative energy options.

Source: Flywheel Publishing Website

Flywheels
A Simple Definition?

- Electromechanical Battery.

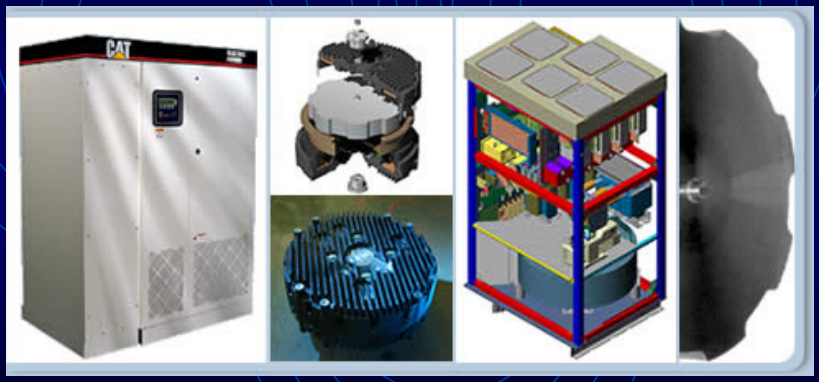
Source: Flywheel Publishing Website

Flywheels
A New Idea?

"Despite its current high-tech appearance, the flywheel is one of society's oldest inventions. (its kin, the potter's wheel, is mentioned in The Bible.). Even the "modern" idea of coupling a flywheel to a generator/motor to emulate a battery for use in electric vehicles is at least four decades old. It dates to the Swiss "Gyrobus,", an urban bus that used a steel flywheel to power a generator/motor and drive it between stops, where a charging trolley was engaged."

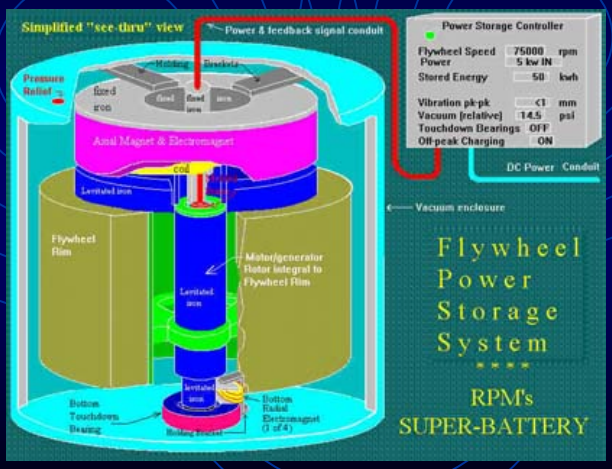
Source:Science & Technology Review April 1996

Flywheels
The Modern Day Incarnation



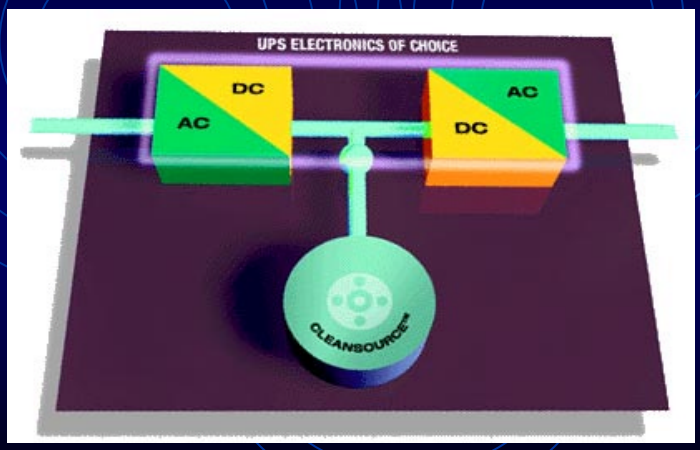
Source: Active Power website

Flywheels
RPM Design Concept



Source: RPM website

Flywheels
The Modern Day Incarnation



Source: Active Power website

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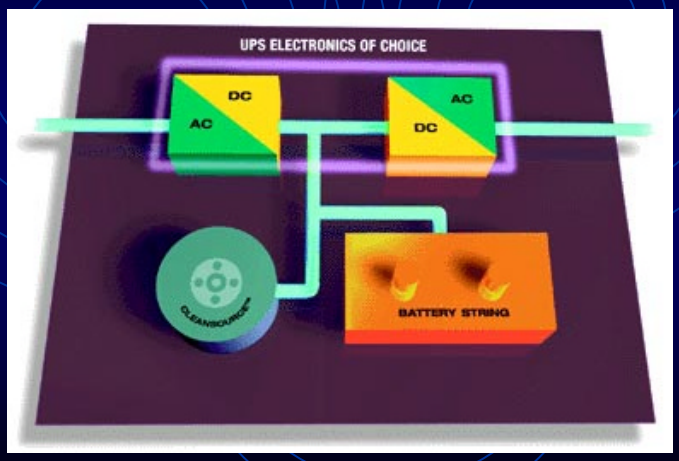

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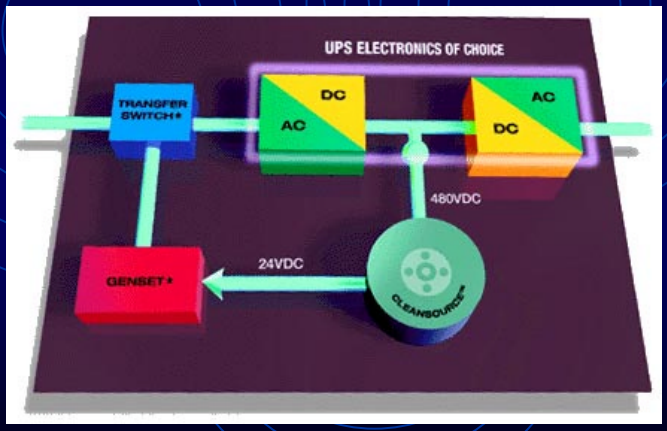


Source: Active Power website

Flywheels
The HNA Project

Simple objectives:

•Provide a voltage ride-through technology which would protect critical computer, telecommunications, and related equipment from "momentary" voltage sags.

•Bring existing UPS system up to dependable performance and reliability levels through installation of new equipment and recycling of existing batteries, and installation of new batteries only to the extent required.

•Flywheel greatly reduces cycling of batteries and extends their lifetime – lower maintenance, reduces environmental impacts.

•Leverage the availability of advanced battery cycler/tester equipment installed at HEVDP under federal funding.

•Allow the future addition of a new emergency generator for periods beyond the capacity of the flywheel and UPS batteries.

Flywheels
The HNA Project

Flywheels

We Can Sell You As Much Capacity As You Want….

Source: Active Power Corporation

Flywheels

The HNA Project

Chronology of Events (i.e. the long, productive road to implementation)

10/21/97 HECO offers proposal to HNA for the installation of a Roesel Motor-Generator.
12/8/97 Bennett Engineers completes a feasibility study for the installation of a 80 KVA Roesel Motor-Generator upstream of the existing UPS system.
3/1/99 Precise Power Corporation's performance testing on 80 KVA RMG is complete. The full load ride-through period falls short of specifications (9 sec. Actual vs. 15 sec. as specified).
3/16/99 Active Power announces the completion of Beta testing of their flywheel with positive results and HECO decides to disengage contract with Precise Power and pursue the integration of the Active Power flywheel/UPS configuration into the design.
6/23/99 HECO offers proposal to HNA for the installation of a 100 KVA Active Power UPS and flywheel system.
8/25/99 HECO issues a purchase order to Powerware (Exide Electronics) for the purchase of an Active Power UPS/flywheel system.
9/8/99 Foxbilt Electric is contracted to install the UPS/flywheel system.
12/31/99 Project is completed and tested.

Flywheels
The HNA Project

Active Power Powerware Flywheel Specifications

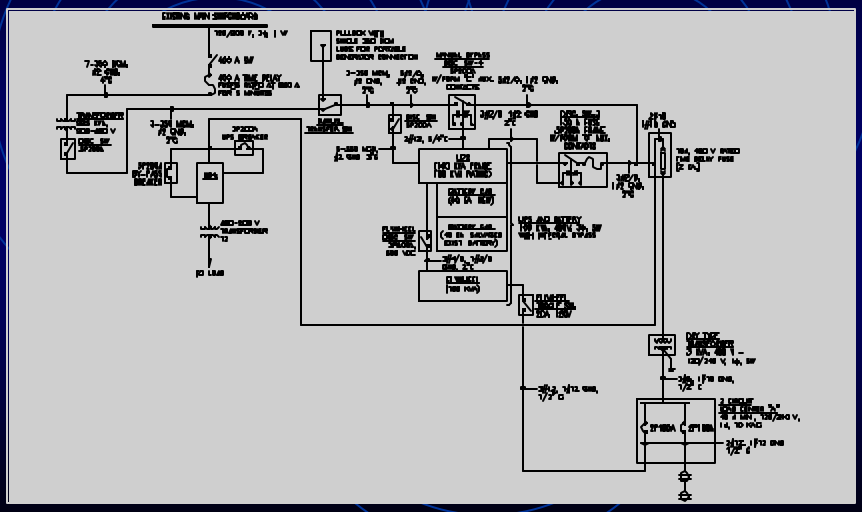
•Model: PF160
•Rating: 160 KVA, 128 KW
•Voltage Input (Float Voltage Range): Adjustable 400 – 600 VDC
•Voltage Output: 360 – 550 VDC
•Full Load Ride-Through Time: 31 seconds at UPS maximum rated load of 80 KW
•Re-Charge Time: Approximately 20 minutes at nominal temperature
•Dimensions: 40” (W) x 40” (D) x 82” (H)
•Weight: 2800 pounds
•Ambient Temperature/RH Range: -20 – 40 deg. C, 0 – 95% RH non-condensing

Flywheels
The HNA Project

Active Power Powerware Plus UPS Specifications

•Model: Powerware Plus 100
•Rating: 100 KVA, 80 KW
•Voltage Input: 480 VAC, 60 Hz, 3-ph, 3-wire
•Voltage Output: 480 VAC, 60 Hz, 3-ph, 3-wire
•Full Load Runtime on Batteries: 27 minutes
•Re-Charge Time: Approximately 20 minutes at nominal temperature
•UPS Dimensions: 49” (W) x 31.5” (D) x 73.5” (H)
•UPS Weight: 3150 pounds
•Batteries: 40 existing and 40 new 12 VDC, 75 AH valve regulated lead acid batteries
•Battery Cabinet (2 ea.) Dimensions: 43” (W) x 31.5” (D) x 73.5” (H)
•Battery Cabinet Weight (With batteries): 3150 pounds
•Ambient Temperature/RH Range: -20 – 40 deg. C, 0 – 95% RH non-condensing

Flywheels
The HNA Project



Flywheels
The HNA Project

Excerpt From EPRI Technical Report:

It is clear that the regulation of the UPS output voltage is excellent. Subjective comments from the customer have been extremely favorable as well. Andy Temporal, a facility engineer at HNA noted, “Since the system has been installed we haven’t noticed any glitches that we used to see prior to the installation.”

Written Pole Motor Generator

The Kahala Mandarin RMG Project

Simple objectives:

Provide a voltage ride-through technology which would protect critical reservation system computers and telephone equipment from “momentary” voltage sags.

Replace function of the existing UPS system through installation of the unique Roesel motor generator (RMG) technology produced by Precise Power Corporation.

Provide voltage support long enough for backup generator to come online and pick up the critical power loads.

Written Pole Motor Generator

The Kahala Mandarin RMG Project

Written Pole Motor Generator

The Kahala Mandarin RMG Project

Chronology of Events (i.e. a parallel, long and productive road to implementation)

12/8/97 Bennett Engineers completes a feasibility study for the replacement of the existing 3 static UPS systems with a 40 KVA Roesel Motor-Generator.

4/29/98 Equipment selection is made for a 15 KVA RMG.

5/7/98 Bennett Engineers completes plans and specifications for project. The design is based on a 15 KVA RMG.

10/5/98 HECO and KMOH decide to install a 25 KVA RMG in lieu of a 15 KVA unit. HECO is given a notice to proceed with the project.

10/19/98 HECO issues a PO to Precise Power for the purchase of a 25 KVA RMG as well as engineering and start-up service.

4/16/99 American Electric completes the installation of the RMG and Precise Power completes initial ride-through tests.

1/9/01 HSI Electrical replaces the 200 A circuit breaker at the input to the RMG with a GE Type SF (Spectra) 250 A Solid State circuit breaker. It was found that the current to the RMG at startup during induction motor mode exceeded 200 A.

10/1/01 Precise Power installs new bearings, automatic re-greasing system for bearings (extends life from 18-36 months), and upgrades microprocessor firmware.

Written Pole Motor Generator

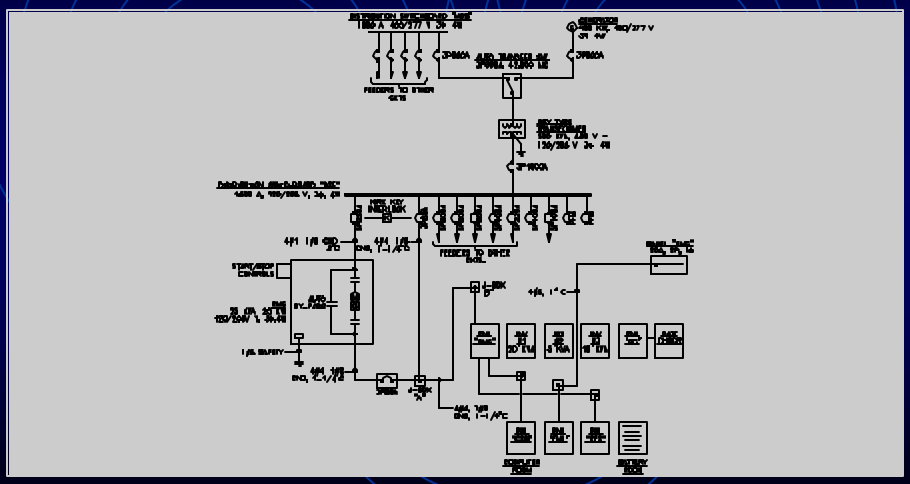
The Kahala Mandarin RMG Project

RMG Specifications

- Model: RMG 201-3-208-25-60
- Rating: 25 KVA, 20 KW (pF = 0.8)
- Voltage Input: 208 VAC, 60 Hz, 3-ph, 4-wire
- Voltage Output: 120/208 Y VAC, 60 Hz, 3-ph, 4-wire
- Full Load Current Out: 69 A at 0.8 pF, 56 A at unity pF
- Full Load Current In: 147 A (max. locked rotor)
- Efficiency: 87%
- Full Load Ride-Through Time: >15 sec. From input blackout
- Frequency Change During Ride-Through: Held to 60 Hz + or – 0.02%
- Dimensions: 48” (L) x 40” (W) x 30” (H)
- Weight: 2600 pounds
- Cooling Air Flow: 1300 cfm
- Ambient Temperature/RH Range: 0 – 45 deg. C, up to 100% RH

Roesel Motor Generator

The Kahala Mandarin Hotel RMG Project



Flywheels

Kahala Mandarin Hotel RMG Project

System has experienced some minor overfrequency and vibration problems which we believe are now corrected with the recent upgrades installed by Precise Power.

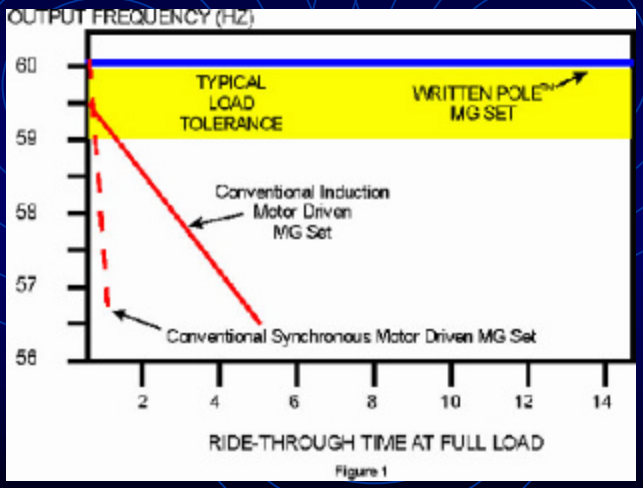
Performance continues to be monitored by HECO.

RMG Technology is used at FAA sites in Hawaii.

5 to 300 kVA units available – units can be paralleled up to 1 MegaVA according to Precise Power.

Written Pole Motor Generator

The Kahala Mandarin RMG Project



Source: Precise Power Corporation

Flywheels & RMGs

Organizations Engaged In The Field

- Precise Power Corporation
- AFS Trinity Power Systems
- Urenco Power Technologies
- Foster-Miller
- Active Power-Caterpillar-Powerware
- Lawrence Livermore National Laboratories
- Argonne National Laboratories
- Regenerative Power and Motion (RPM)

Flywheels

A Most Interesting Link

- Urenco Power Technologies Website:

  Uranium enrichment services

- The Urenco Group provides a high quality, cost effective and reliable uranium enrichment service to nuclear power utilities worldwide. Urenco's plants employ the gas-centrifuge process. The process is clean, safe, and efficient.
- Conclusion? Gas-centrifuge → Flywheels

Flywheels

Examples of Research Areas

- Development of a rapid filament winding process for glass and carbon reinforced epoxy and polyurethane matrix rotors.
- Development of a vacuum spin chamber for testing of rotors up to 14" in diameter at higher rotational speeds.
- Use of High Critical Temperature (Tc) superconducting elements in stator components to eliminate need for position sensors and elaborate feedback control systems.
- Measurement of strain in high speed rotors with optoelectronic devices.
- Determination of fatigue behavior of composite rotor material using coupon tests

Flywheels

The State-of-the-Art (in 1996)

- "Operation at over 100 kW of power and storage of more than 1 kWh of energy have been demonstrated using compact rotors and integrated containment structures. Prototype rotors have been tested at 60,000 rpm and have exceeded a specific power of 8 kW/kg with a measured energy recovery efficiency of 92%."

Source:Science & Technology Review April 1996

Flywheels

Good Article On The Internet

- http://www.llnl.gov/str/pdfs/04_96.2.pdf

Flywheels & RMGs

Good Contacts At HECO

- Mark Yamamoto at 543-4608
- Derek Fujikami at 543-4635
- Norman Nakagawa at 543-4761